


Multipoint statistics and large scale structures of turbulence

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PRINCIPAL INVESTIGATORS : Prof.Dr. Joachim Peinke (Chair of excellence), Alain Girard (Grenoble contact), **Emeric Durozoy** (PhD student), Mathieu Gibert (PhD supervisor), S. Kharche (PhD CEA and Oldenburg), André Fuchs (Oldenburg).

The main focus of the work is to apply comprehensive stochastic analysis methods, yielding to multipoint characterizations of turbulence. This stochastic approach is set in the context on non-equilibrium thermodynamics, to achieve a new understanding of turbulent fluctuations, intermittency and extreme events. Moreover, thanks to the collaboration built around this project, our vision is to extend this comprehensive approach for ideal isotropic turbulence to non-classical fluids in low temperature helium flows, where quantum effects emerge in the Eulerian and Lagrangian framework as well as non-ideal turbulence like for instationary conditions which is important for example for real life wind conditions.

The Eulerian framework : To apply this highly demanding analysis in the Eulerian framework, we used the SHREK (Superfluid à Haut Reynolds en Ecoulement de von Karman) experiment at INAC. This extreme experiment (3000 L of liquid He) is able to generate unprecedented high Reynolds numbers in stable laboratory conditions in various conditions. By changing the rotation speeds a continuous transition to a pulsing (instationary) turbulent state can be achieved. We used micron-sized hot wires (Fig. 1) in order to acquire turbulent fluctuations for hours and converge the high order statistics in the signal (rare events). The preliminary results obtained [A. Fuchs, 2017] indicate that the Integral Fluctuation Theorem is a new fundamental law for turbulence and holds even for highest Reynolds numbers achievable in laboratory conditions.

The Lagrangian framework : In this framework we used the Cryogenic Lagrangian Exploration Module (CryoLEM) at the Néel Institute. This cryostat is equipped with multiple angle optical access in order to perform 3D Lagrangian Particle Tracking (3D-LPT) on micron-sized particles evolving in turbulent helium-4 fluid or superfluid flow. Moreover, this experiment is entirely setup on a spinning table (up to 2 revolutions per second) to study the influence of rotation on the different turbulent flows generated and control their anisotropy. We have obtained in early 2018 the first Lagrangian particle trajectories in a rotating cryogenic turbulent flow (Fig. 2). Our aim is now to adapt our stochastic analysis to this moving frame of reference.

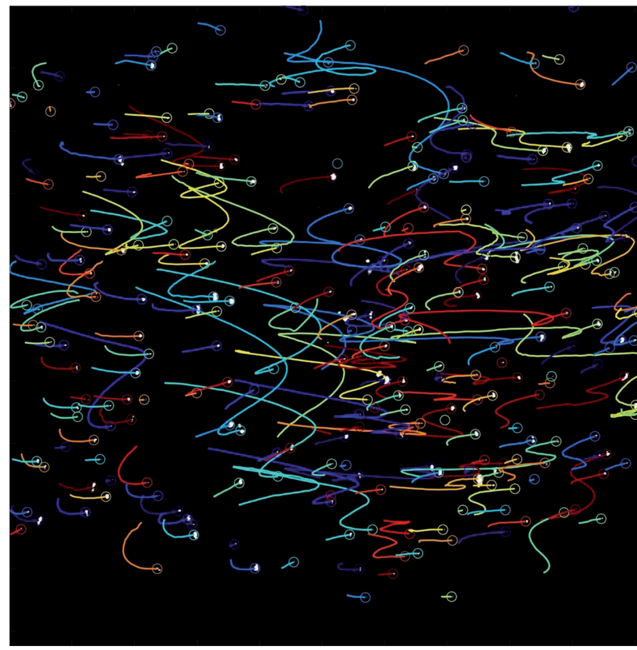

Fig. 2: Lagrangian trajectories obtained in the CryoLEM

Within a cooperation with Martin Obligado (LEGI) a new characterization of the turbulent structure of wind turbines could be worked out.

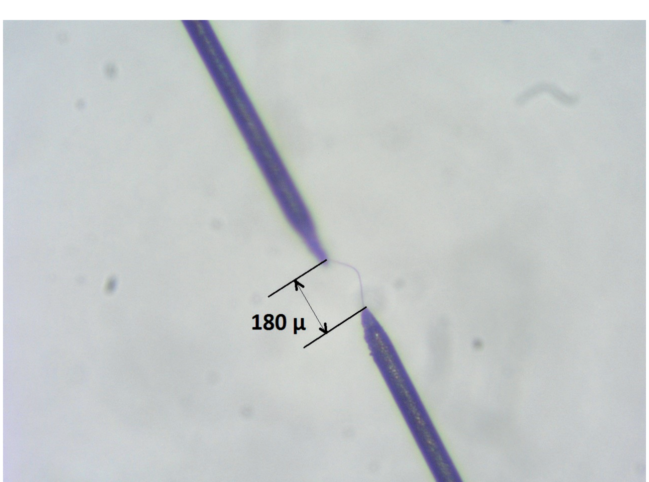

Fig. 1: Micron size (180 µm long) Wollaston hot wire

OUTCOMES

Oral presentations:

-A. Fuchs, ETC Conference, Stockholm, 2017

-Quantum Turbulence Workshop April 10 - 12, 2017 Tallahassee, Florida.

-Chasing tornadoes: vorticity above, below, and in the lab 9-11 April 2018, Newcastle.

Collaboration:

The European EUHIT program supported part of the Work

LANEF Workshops:

-Measurement Methods in Turbulence, 5-7 July 2017 (NEEL)

-Workshop on Fluctuations, Large Deviations in Turbulence, 28-30 August, Autrans (2017)

Leverage: Extension of collaboration to LEGI, Grenoble.